


AWARD/CONTRACT		1. THIS CONTRACT IS A RATED ORDER UNDER DPAS (15 CFR 700)		RATING		PAGE OF PAGES 1 2	
2. CONTRACT (Proc. Inst. Ident.) NO. EP-C-17-031/68HERC22F0163				3. EFFECTIVE DATE See Block 20C		4. REQUISITION/PURCHASE REQUEST/PROJECT NO. PR-ORD-22-00170	
5. ISSUED BY CODE		CAD		6. ADMINISTERED BY (If other than Item 5) CODE			
CAD US Environmental Protection Agency 26 West Martin Luther King Drive Mail Code: W136 Cincinnati OH 45268-0001							
7. NAME AND ADDRESS OF CONTRACTOR (No., street, country, State and ZIP Code) TETRA TECH, INC. Attn: George Townsend 10306 EATON PL STE 340 FAIRFAX VA 22030				8. DELIVERY <input type="checkbox"/> FOB ORIGIN <input checked="" type="checkbox"/> OTHER (See below)			
				9. DISCOUNT FOR PROMPT PAYMENT			
				10. SUBMIT INVOICES (4 copies unless otherwise specified) TO THE ADDRESS SHOWN IN		ITEM	
CODE 198549560		FACILITY CODE					
11. SHIP TO/MARK FOR CODE		CAD		12. PAYMENT WILL BE MADE BY CODE			
CAD US Environmental Protection Agency 26 West Martin Luther King Drive Mail Code: W136 Cincinnati OH 45268-0001							
13. AUTHORITY FOR USING OTHER THAN FULL AND OPEN COMPETITION: <input type="checkbox"/> 10 U.S.C. 2304 (c) () <input checked="" type="checkbox"/> 41 U.S.C. 3304 (a) (1)				14. ACCOUNTING AND APPROPRIATION DATA See Schedule			
15A. ITEM NO	15B. SUPPLIES/SERVICES			15C. QUANTITY	15D. UNIT	15E. UNIT PRICE	15F. AMOUNT
	Continued						
15G. TOTAL AMOUNT OF CONTRACT						\$59,959.00	
16. TABLE OF CONTENTS							
(X)	SEC.	DESCRIPTION	PAGE(S)	(X)	SEC.	DESCRIPTION	PAGE(S)
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	B	SUPPLIES OR SERVICES AND PRICES/COSTS		PART III - LIST OF DOCUMENTS, EXHIBITS AND OTHER ATTACH.			
	C	DESCRIPTION/SPECS./WORK STATEMENT			J	LIST OF ATTACHMENTS	
	D	PACKAGING AND MARKING		PART IV - REPRESENTATIONS AND INSTRUCTIONS			
	E	INSPECTION AND ACCEPTANCE			K	REPRESENTATIONS, CERTIFICATIONS AND OTHER STATEMENTS OF OFFERORS	
	F	DELIVERIES OR PERFORMANCE			L	INSTRS., CONDS., AND NOTICES TO OFFERORS	
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CONTRACTING OFFICER WILL COMPLETE ITEM 17 (SEALED-BID OR NEGOTIATED PROCUREMENT) OR 18 (SEALED-BID PROCUREMENT) AS APPLICABLE							
17. <input checked="" type="checkbox"/> CONTRACTOR'S NEGOTIATED AGREEMENT (Contractor is required to sign this document and return _____ copies to issuing office.) Contractor agrees to furnish and deliver all items or perform all the services set forth or otherwise identified above and on any continuation sheets for the consideration stated herein. The rights and obligations of the parties to this contract shall be subject to and governed by the following documents: (a) this award/contract, (b) the solicitation, if any, and (c) such provisions, representations, certifications, and specifications, as are attached or incorporated by reference herein. (Attachments are listed herein.)				18. <input type="checkbox"/> SEALED-BID AWARD (Contractor is not required to sign this document.) Your bid on Solicitation Number 68HERC22R0054, including the additions or changes made by you which additions or changes are set forth in full above, is hereby accepted as to the items listed above and on any continuation sheets. This award consummates the contract which consists of the following documents: (a) the Government's solicitation and your bid, and (b) this award/contract. No further contractual document is necessary. (Block 18 should be checked only when awarding a sealed-bid contract.)			
19A. NAME AND TITLE OF SIGNER (Type or print)				20A. NAME OF CONTRACTING OFFICER Mark Cranley			
19B. NAME OF CONTRACTOR TETRA TECH, INC.		19C. DATE SIGNED		20B. UNITED STATES OF AMERICA BY  (Signature of the Contracting Officer)		20C. DATE SIGNED 02/15/2022	
BY _____ (Signature of person authorized to sign)							

CONTINUATION SHEET	REFERENCE NO. OF DOCUMENT BEING CONTINUED EP-C-17-031/68HERC22F0163	PAGE	OF
		2	2

NAME OF OFFEROR OR CONTRACTOR
TETRA TECH, INC.

ITEM NO. (A)	SUPPLIES/SERVICES (B)	QUANTITY (C)	UNIT (D)	UNIT PRICE (E)	AMOUNT (F)
0001	DUNS Number: 198549560 TOCOR: Sylvia Lee Delivery: 09/30/2022 Accounting Info: 21-22-C-26D2000-000FK7XR4-2532-26A6F-2226D2CR12-001 1 BFY: 21 EFY: 22 Fund: C Budget Org: 26D2000 Program (PRC): 000FK7XR4 Budget (BOC): 2532 Cost: 26A6F DCN - Line ID: 2226D2CR12-001 Period of Performance: 02/10/2022 to 09/30/2022 FFP CLIN for development of Diatom-based tools for assessment and criteria development, and sediment core chronology data for bottom core samples from northeast lakes in accordance with the PWS attached. Product/Service Code: R499				59,959.00

PERFORMANCE WORK STATEMENT
Contract Number (Tetra Tech, Inc.) EP-C-17-031
PR-ORD-22-00170
TO # 68HERC22R0054

I. TITLE: Sediment core chronology data for bottom core samples from northeast lakes

II. EAS SHORT TITLE: Sediment core chronology

III. TASK ORDER COR:

Task Order COR (TOCOR)	Alternate Task Order COR (ATOCOR)
Name: Sylvia Lee Office: ORD/CPHEA/IEAB-D 1200 Pennsylvania Ave., NW (MC 8623R) Washington, DC 20460 Phone: 773-456-4151 Email: Lee.sylvia@epa.gov	Name: Emily Nering Office: Region 2 2890 Woodbridge Avenue Edison, NJ Phone: 732-321-6764 Email: Nering.emily@epa.gov

IV. PERIOD OF PERFORMANCE: Date of Task Order award through September 30, 2022.

V. BACKGROUND:

The EPA Office of Research and Development's Integrated Environmental Assessment Branch-DC works to build the capacity of EPA program and regional offices, state water managers, and other decision-makers to assess and develop benchmarks for the protection of water quality and aquatic ecosystems. Research and assessment activities broadly support EPA's mission and responsibilities as defined by the Clean Water Act and the Safe Drinking Water Act. IEAB leads projects in the Region Applied Research Effort (RARE) program that provide technical assistance supporting regional needs.

RARE projects with EPA Regions 1 and 2 began in 2019 to harmonize lake diatom taxonomic data from northeast states and application of the harmonized data to support nutrient, aquatic life, and other water quality goals in a regionally consistent approach not limited by state boundaries. The diatom data are from sediment cores taken between 1991 and 2018 from 607 lakes, totaling 1327 core samples from Maine, Vermont, Massachusetts, New Hampshire, Connecticut, Rhode Island, New York, and New Jersey. Siliceous remains of diatoms preserved in sediments are commonly used to track environmental change in lakes and their watersheds. Analysis of multiple intervals throughout the sediment core is ideal for obtaining a more complete paleolimnological record of the lake and is necessary for estimating how far back in history the intervals represent. To conserve resources, only the top

and bottom intervals of the sediment cores were retained from northeast lakes in the dataset. The top of the sediment cores represents modern diatom assemblages and lake conditions near the time of sampling. It is more difficult to estimate the time represented by the bottom layer of the sediment core, due to variation in lake sedimentation rates and other factors such as land management. For lakes with relatively low sedimentation rate, it may be fair to assume the bottom of the core is associated with a time prior to major anthropogenic disturbance (e.g., pre-industrial 1850 AD or pre-European colonization) that could be a useful reference for how much impairment the lake has undergone. By contrast, a sediment core sample from a lake with more rapid sedimentation may not represent environmental conditions far enough in the past to be a useful reference point.

Fortunately, numerous paleolimnological studies throughout the northeastern United States were conducted in the past to understand long term trends such as lake acidification and eutrophication. Many of these studies included biological and chemical profiles of sediment cores at multiple intervals and developed a chronological model to relate core depths to times in the past (e.g., dating profiles in Figure 1). It is possible to find these data in the literature and in online databases, such as Neotoma (Figure 2. <https://apps.neotomadb.org/explorer/>).

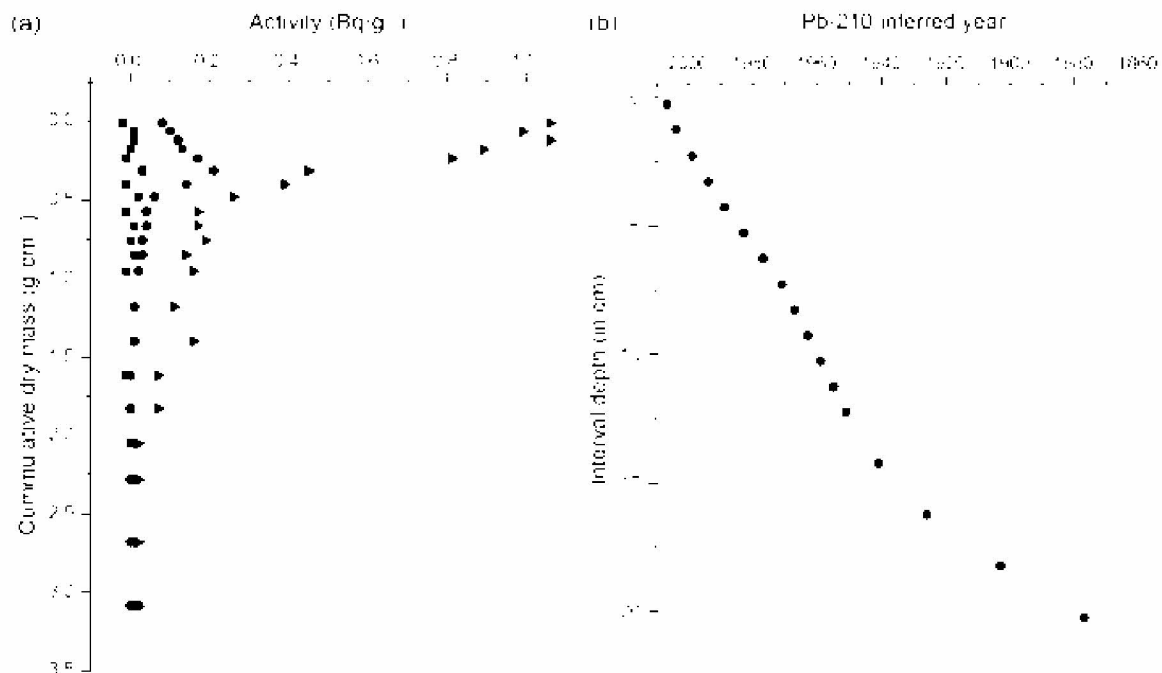
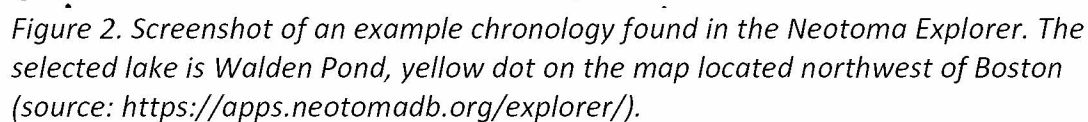


Figure 1. Figure showing Lead-210 inferred year and sediment interval depth. Example is from a study of Big Moose Lake, New York by Arseneau et al. 2011 <https://doi.org/10.1139/f2011-003>.


$$\text{Log}(\text{Mean SAR}_{1850\text{-Present}}) \text{ (mm yr}^{-1}\text{)} = 0.50 + 0.15 \times \log(\text{Mean Cropland}_{1850\text{-Present}} + 1) \text{ (km}^2\text{)} \\ + 0.012 \times \text{Mean Temperature}_{1850\text{-Present}} \text{ (}^{\circ}\text{C)} - 2.8\text{e-}3 \times \text{Altitude}^{1/2} \text{ (m. asl)} - 7.7\text{e-}4 \times \text{Mean} \\ \text{Precipitation}_{1850\text{-Present}} \text{ (mm)}$$

3

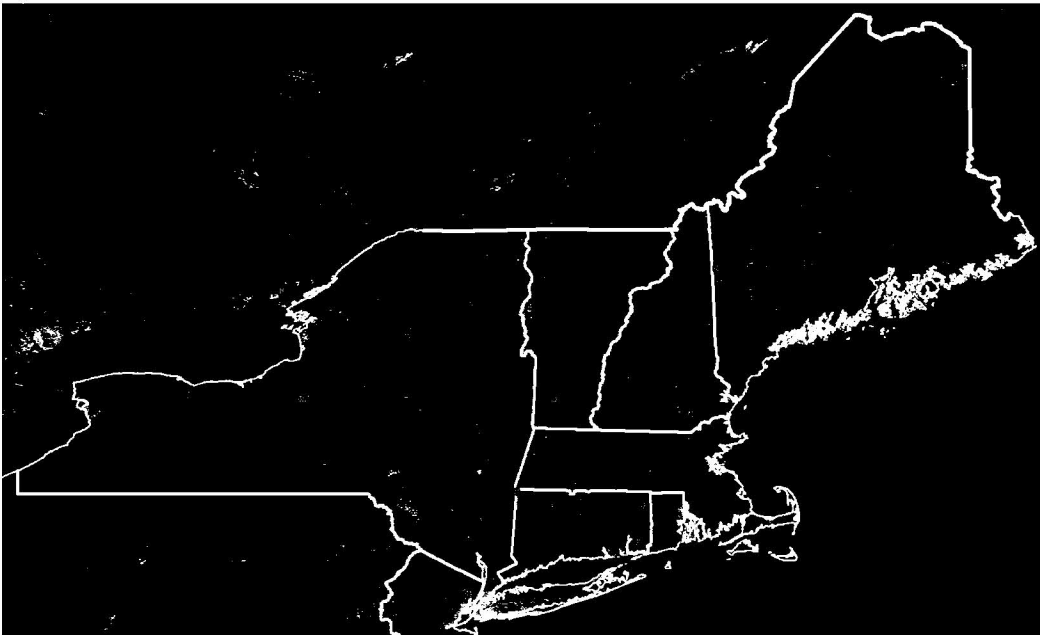


Figure 3. Map of northeastern U.S. lakes included in Baud et al. 2021.

VI. PURPOSE OF THIS TASK ORDER (TO):

This TO supports EPA ORD RARE project with Regions 1 and 2 to mine available datasets and the literature to understand years in the past represented by the bottom layer of sediment core samples taken with gravity cores (Dixit et al. 1999). This information will provide important context for using top and bottom sediment core diatom assemblages to assess lake aquatic life and water quality condition.

A major goal of the TO is to determine which lakes in the RARE project have data from bottom core samples that represent pre-European and/or pre-industrial times (circa 1700-1850 AD). Pre-European age is ideal due to the history of early human impacts in the northeastern U.S., but more difficult to estimate than pre-industrial age. The TO will also identify knowledge gaps (i.e., types of lakes lacking sediment core chronological information in the available literature and datasets) to inform whether it is necessary to take new sediment cores for multi-interval age analysis or deeper cores to sample older sediments.

VII. DESCRIPTION OF TASKS:

Task 1: **Communication and QAPP development**

SubTask 1.1. **Communication and Regular Reporting**

The contractor shall schedule monthly project meetings throughout the period of performance of this Task Order. Additional meetings shall be scheduled as necessary when requested by the TOCOR.

Deliverable 1.1.A: Monthly conference calls to provide status updates. Due each month for the duration of this TO or as requested by the TOCOR.

Deliverable 1.1.B: Each monthly conference call shall be reported in meeting notes as email and sent to the TOCOR within three (3) days of the monthly call.

SubTask 1.2. Develop a QAPP

All work conducted under this task order shall be performed pursuant to an EPA-approved Quality Assurance Project Plan (QAPP). The draft QAPP with EPA QA ID: L-HEEAD-0033275-QP-1-0, shall be submitted for review to the TOCOR and the EPA QA Manager 14 days after TO award. The draft QAPP shall be in conformance with EPA's *Requirements for Quality Assurance Project Plans* (EPA QA/R-5). (<https://www.epa.gov/quality/epa-qar-5-epa-requirements-quality-assurance-project-plans>)

All electronic deliverables (i.e., computer files) shall be submitted in a format acceptable to EPA.

Tasks 2 through 3 may not begin until receiving in writing from the EPA TOCOR that EPA QA has approved the QAPP.

Deliverable 1.2.A: Draft QAPP submitted to the TOCOR for review 14 days after TO award.

Deliverable 1.2.B: Final QAPP addressing TOCOR's and QA officer's comments on the QAPP due one (1) week after receiving comments from the TOCOR.

Task 2 – Add sedimentation rate predictors and chronology data to RARE project's northeast lake dataset and test SAR equation

The Contractor shall, in consultation with the TOCOR, add data for sedimentation rate predictor variables to the 607 lakes in the RARE project's northeast lake dataset (coordinates, COMIDs, lake names, and additional site information to be provided by the TOCOR). Predictor variables and data sources as described in Baud et al. (2021) include:

- (1) log-transformed average cropland density (total cropland area, in km² per 9 km² grid cell) averaged between 1850 to present
 - a. Source: Hyde 3.2

- (2) annually averaged mean monthly temp, averaged across 1850 and present
 - a. Source: NOAA National Climatic Data Center
- (3) square-root transformed altitude
 - a. Source: Google Earth Pro
- (4) annual sum of mean monthly precipitation averaged between 1850 and present
 - a. Source: NOAA National Climatic Data Center

To test the performance of the SAR equation for northeast U.S. lakes, the Contractor shall extract chronology data for up to 300 lakes to match the sediment core bottom intervals in the RARE project dataset with year from lake-specific age models in Neotoma. The Contractor shall compare the age model-inferred years with the results of the SAR equation based on predictor variables. The SAR equation was designed to infer the sediment depth of pre-industrial times, but this project requires inference to deeper sediment depths corresponding to pre-European colonization of the northeastern U.S. In addition, the lakes in the northeastern U.S. have a wide variety of morphological, historical, and land use characteristics that influence sediment accumulation rates. To tackle this novel research question, the Contractor shall use their expertise and creative thinking to use the existing data and age-inference models to develop a method for estimating sediment depths for several types of lakes back to pre-European colonization and for understanding the uncertainty around those estimates. The Contractor shall not exceed 300 hours on this task.

Deliverable 2.1: Dataset with predictor variables matched to RARE project lakes.

Deliverable 2.2: Results of applying the SAR equation using the predictor variables in Deliverable 2.1.

Deliverable 2.3: Dataset from Deliverable 2.1 with added age model-inferred years from Neotoma matched to bottom interval depths.

Deliverable 2.4: Interim results comparing SAR equation-estimated years with age model-inferred years and proposal for estimating pre-European colonization sediment depths depending on lake type.

Deliverable 2.5: Finalized results and results of the selected method for estimating pre-European colonization sediment depths depending on lake type.

Task 3 – Develop a report synthesizing data and identifying knowledge gaps

The Contractor shall, in consultation with the TOCOR, develop a report on the performance of the SAR equation when applied to northeast lakes and Contractor's recommendations to use SAR equation or a different approach (e.g., modifying the SAR equation, using literature, taking new sediment cores). The Contractor shall use their expertise and experience with lake assessments to ensure the recommendations in the

report will help further the goals of the northeast states (i.e., using diatoms from the tops and bottoms of sediment cores to assess lake biological condition across the region). The Contractor shall not exceed 150 hours on this task.

Deliverable 3.1: Draft report

Deliverable 3.2: Final report

VIII. SCHEDULE OF BENCHMARKS & DELIVERABLES:

Task No.	SubTask No.	DELIVERABLE	Incremental Schedule
1	1.1	1.1.A. Monthly conference calls or as requested by the TOCOR	Due each month for the duration of this TO or as requested by the TOCOR
1	1.1	1.1.B. Each monthly conference call shall be reported in meeting notes as email	Due within 3 days after the monthly call
1	1.2	1.2.A. Draft QAPP	Due 14 days after TO award
1	1.2	1.2.B. Final QAPP	Due 1 week after TOCOR comments
2	2.1	2.1. Dataset with predictor variables	Due to TOCOR 8 weeks after award
2	2.2	2.2. Results of applying the SAR equation	Due 2 weeks after receiving TOCOR comments on Deliverable 2.1.
2	2.3	2.3 Dataset with age model-inferred years from Neotoma	Due 6 weeks after receiving TOCOR comments on Deliverable 2.2.
2	2.4	2.4 Interim comparison results	Due 2 weeks after receiving TOCOR comments on Deliverable 2.3
2	2.5	2.5 Final comparison results	Due 2 weeks after receiving TOCOR comments on Deliverable 2.4
3	3.1	3.1. Draft	Due to TOCOR 8 weeks after completing Deliverable 2.5.
3	3.2	3.2. Final	Due 8 weeks after receiving TOCOR comments on Deliverable 3.1.

IX. ACCEPTANCE CRITERIA:

The Contractor shall prepare high quality deliverables. Deliverables shall be edited for grammar, spelling, and logic flow. The technical information shall be reasonably complete and presented in a logical, readable manner. Figures submitted shall be of high quality, similar to those in presentations developed for national scientific meetings and should be formatted as jpeg or png files. Spreadsheet, report, and database deliverables shall be compatible with Microsoft Office 365 (i.e., MS Excel, MS Word, Adobe pdf, or MS Access files depending on the task and deliverable).

X. REFERENCES:

Arseneau, K.M., Driscoll, C.T., Brager, L.M., Ross, K.A. and Cumming, B.F., 2011. Recent evidence of biological recovery from acidification in the Adirondacks (New York, USA): a multiproxy paleolimnological investigation of Big Moose Lake. *Canadian Journal of Fisheries and Aquatic Sciences*, 68: 575-592. <https://doi.org/10.1139/f2011-003>

Baud, A., Jenny, J. P., Francus, P., & Gregory-Eaves, I. 2021. Global acceleration of lake sediment accumulation rates associated with recent human population growth and land-use changes. *Journal of Paleolimnology*, 66: 453-467. <https://doi.org/10.1007/s10933-021-00217-6>

Dixit, S. S., Smol, J. P., Charles, D. F., Hughes, R. M., Paulsen, S. G., & Collins, G. B. 1999. Assessing water quality changes in the lakes of the northeastern United States using sediment diatoms. *Canadian Journal of Fisheries and Aquatic Sciences*, 56: 131-152. <https://doi.org/10.1139/f98-148>